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Diarrhea in the Infant: The Various Etiological Factors.

By

B.H.H. Hay

Diarrhea in the Infant: The Various Etiological Factors.

There are very few, if any, practitioners of medicine who have not, at one time or another, been confronted with diarrhea in the infant. The term, diarrhea, is used here to include all conditions attended by frequent, loose evacuations of the bowels. The importance of diarrheal diseases in children can be appreciated by physicians, not only because they are confronted by this distressing condition so often, but because diarrhea, a few years ago, was the cause of more deaths than any other condition which visited the child. The International List of the Causes of Death(1), based on the 1929 census, shows that even at that late date, one in every nine deaths under one year of age was due to diarrhea and enteritis. This being the state of affairs, I believe that all of us can benefit by a study of the etiology of this condition because, without a knowledge of the cause, therapeutics is not only difficult, but hopeless.

Delving into the past we find that, even as early as Hippocrates, diarrhea was one of the diseases of infancy. Quoting one of the Hippocratic aphorisms(2) we find that: "The diseases of the newborn and of infants are aphthae, vomiting, insomnia, night fears, inflammation of the umbilicus and discharge from the ears; at teething there are pruritis of the gums, convulsions and Diarrhea, especially when cutting the canine teeth, and in fat constipated infants."

Aretaes, The Cappadocian(2), writing in the second century, speaks of cholera infantum, which is a more severe form of diarrhea. He says: "Cholerae infantum is a retrograde movement of the material in the whole body on the stomach, the belly and the intestines; a most acute illness. Those matters then which collect in the stomach, rush upwards by vomiting; but those humors in the belly and intestines, by the passages downwards. With regard to appearance then, those things which are first discharged by vomiting are watery; but those things by the anus are fetid and liquid excrement, for continual indigestion is the cause of this disease; but if these are washed out, the discharges are bilious at first, indeed they are borne easily and without pain; but afterwards the stomach is affected with retching and the belly with toxemia." As to the seasons, he says: "The season of summer, then, engenders the affection, next autumn, spring less frequently, winter least of all."

Oribasius(325-403)(2) in his Synopsis, has an article On the Upbringing of Children which indicates that in his time overfeeding the children caused diarrhea. He says: "For those who, at the period of weaning, stuff them with food and endeavor to give them rich nourishing foods will pervert their nutrition and prevent their growth from the very weakness of their natures. Some of these children will be affected with ulcerations and inflammations of the intestines and with grave disease, resulting from the frequency of indigestion and diarrhea."

Rhazes(862-932)(2) says that ~~in~~ infants are frequently troubled with flux of the bowels, whether from teething, from

catching cold, from spoiling of the milk by cholera (bile) and phlegm: and the signs of cholera are acidity and acridity of the stools, which are rapidly evacuated; and the signs of cold and phlegm are light colored stools, griping pains in the abdomen on evacuation which is instantaneous, unless the phlegm be viscid.

From the above notations, we are able to ascertain ^{that} the clinicians in the past had the same problems to deal with that the present day practitioners have. The reference to the etiology is more or less based on generalities, but since Pediatrics, as a separate branch of medicine, was not developed until the advent of printing, it is quite difficult to find much in the historical literature on the diseases of children.

Up until the time that Pediatrics became a separate division of medicine, the causes of the various diseases were attributed to the various seasons, the food and the improper amounts of the several body fluids. As time passed, the men of science (laboratory) became interested and from that time on they have been seeking for the truth. Much work has been done, but it was not until the nineteenth century that the more modern and acceptable work was developed. Of course, since that time, much of the work has been proven to be in error, but I believe that we owe it to these pioneers to mention some of their work in this paper.

John Cheyne (3) 1814, in his book, Of the Bowel Complaints

laints says: "The history of the Disease, Weaning brash(similiar to diarrheal diseases) instructs us in the precaution to be used for providing against it. If the observation which I have ~~made~~ made be just, that it happens much oftener in the autumn than at any other time of the year, it will be readily agreed that delicate children should, at that season, be kept a month or two longer on the breast." He, of course, places the cause of the disease on teething and improper diet. He says: "The exciting cause of the disease I consider to be too sudden an alteration of the diet of a child." Basing his reasoning on these facts, he paid strict attention to the diet. These are his words: "An animal diet produces less irritation than a vegetable." He also advocated the use of breast milk saying: "I have wished for an opportunity of restoring the breast milk to a child, as I am convinced that it would be useful. He also believed that that a "morbid state of bile" was one of the most common causes of the diarrheas. As will be noted again, these old writers had ideas and treated their patients accordingly, but they had no proof, other than that the patients recovered under the treatment. So they reasoned that many of their ideas were right, and in many instances they were correct. In fact many of their ideas have not been changed, only proven.

Billard, 1840, (4) a Parisian physician, had more evidence for his statements, because he had examined many of his cases on the autopsy table. In speaking of intestinal indigestion which is manifested by diarrhea, he says: "Sometimes the digestive tube is inflamed, ulcerated and disorganized to a

greater or lesser extent, but the white softening is the lesion most frequently met with in the children that have died from the disease." In the year 1826, he examined after death fifteen cases of chronic diarrhea without inflammation in children from the age of fifteen days to two months. In eight, there were no lesions, but the abdomen was distended with gas together with white frothy fluid matters found in the intestinal tube. He further states that everything connected with this subject leads to the belief that this defect of nutrition consists in the nature of the food the infant is subjected to. In truth all of the children at the Hospice des Enfants Trouves (Paris) and who are confided to the care of the wet nurses are pale, thin and in a bad condition. A great number perish in this hospital from imperfect nutrition. In almost all, the symptoms which they present, even to the time of their death arise from an evident disturbance of the digestive function. In all probability, this wasting arises from suckling of the children by women who have for a long time discharged the office of nurse and who by changing the child frequently feel a perfect indifference for one placed under their care and establish no regular hours for suckling, nor fix upon the quantity of milk for the child; so that always hungry from receiving but little substantial nourishment, it takes too large a quantity at a time of a liquid which, from its superabundance and poor quality, is hurtful."

Billard also says that suckling by the mother ought not to be considered so generally and exclusively necessary as to be deemed the only means suitable for nourishing feeble

infants. Every mode of alimentation should be tried and that adopted which is found best for the digestive apparatus of each infant. He groups the causes of the intestinal disturbances together as the, injection of the intestinal tube at birth, the facility with which this apparatus becomes injected, producing very considerable congestion upon the slightest disturbance occurring in the course of the blood in the thoracic and abdominal vessels, the ingestion of ailments too stimulant, too nutritive or too difficult to digest and, lastly, the functional activity of the digestive apparatus from birth.

The beginning of the twentieth century ushered in a period of experimental medicine which we are still enjoying. Of course much of the work was later found to be only partially correct, nevertheless, much of the present day knowledge is essentially that of thirty or more years ago.

At this time I am going to digress for a brief period and bring into the discussion a little work done on the *Bacillus dysenteriae* as a cause of infantile diarrhea. The majority of this paper is an elaboration of the causes of diarrhea based, more or less on a nutritional and constitutional basis, rather than an infectious basis, however, a paper on the etiology of infantile diarrhea would not be complete without mention of the latter.

Charles W. Duval and Victor H. Bassett (5) writing in their report of the Etiology of Summer Diarrhea in Infants 1902,

state that the successful studies of Japanese dysentery by Shiga in 1898 which led to the isolation of B.dysenterae and the demonstration that it was the cause of acute dysentery, were followed by the studies of acute dysentery in Germany by Kruse in 1901, with results confirming the observations of Shiga. Since that time a considerable number of observations, bearing upon and extending the studies just mentioned have been carried out both in the United States and elsewhere.

The idea that the summer diarrhea of infants had an infectious origin had long been believed by clinicians and pathologists, but up until this time, 1902, no work had been done about it.

Duval and Bassett(5) in the summer of 1902 set about to investigate the intestinal bacteria of infants suffering from different forms of summer diarrhea, especially to the presence of the Bacillus dysenterae(Shiga). They used normal stools for controls and found that stools containing blood and mucous are especially favorable for isolating the B. dysenterae. They also tested the stools of some children which showed no blood and they did not find either, organisms or agglutination reaction.

They contended from this study that there was little doubt but that the B.dysenterae was a very important causal factor in ~~the~~ relation to the summer intestinal diseases of children, but they further stated that as yet it would be impossible, or better, premature to conclude from our studies that all cases

of summer diarrhea are caused by the B.dysenterae.

J.H.Mason(5)working along the same lines divided his summer diarrheas, based on his experimentation into two groups, (1) acute gastro-intestinal infections, a dyspeptic diarrhea. This group showed little evidence if any of being associated with destructive intestinal lesion. (2) Ileo-colitis, dysentery or destructive inflammatory diarrhea accompanied by greater prostration and often times fatal termination.

Frederick R.Gray and E.M.R.Stanton(5),working on material from Bellevue Hospital, came to the conclusion that B.dysenterae can be found in all cases,possibly, of infantile diarrhea in which the discharge contains mucous, whether or not it is accompanied by blood.

Martha Wollstein(5) states that in the normal stools of young infants during life and in the upper layers of the normal intestinal mucosa at autopsy,B.dysenterae is not found,However, it may be present in cases of mild catarrhal inflammation of the colon either,as a terminal infection, or,as the remains of a previously active infection, when the clinical manifestations do not warrant the diagnosis of dysentery.

Ralph Vincent(6),in 1911, explained the diarrhea in this way; He said that there are two classes of organisms in milk; those that produce acid in the milk and those that do not. The acid producing organisms always present in milk are very

seldom found in places not handling milk. There are, however, only a few colonies that arise from the acid producing colonies. These organisms are found in the exterior portion of the duct of the mammary gland. If milk is kept at incubator temperature these lactic organisms increase in number tremendously. Most of the adventitious organisms are quite unable to grow in an acid medium.

He makes the comparison between cows milk(fat 4%, lactose 4.5%, albuminoid 3.5%) and human milk. The human milk has more than one half of the total solids, lactose. This is twice as much as the fat and more than three times that of albuminoid. He says: "The susceptibility of the human infant to intestinal affection is compensated for by the presence in its natural food of an exceptional amount of lactose."

If the milk is boiled, the lactic organisms are killed and since they do not possess spores the agents of lactic fermentation are destroyed. This is not true of the putrefactive bacteria. They possess spores and these spores are not injured by boiling and these in turn act upon the proteins in a proteolytic manner, causing diarrhea. These bacteria are always present in the normal alimentary canal, but as long as there is lactic acid present(normal condition)these organisms are inert. Vincent further claims that, since boiling the milk destroys the lactic acid formers, raw milk should be used exclusively in feeding the infants.

Platt(7) in 1916, working in New York, studied the diarrheal conditions in infants from the public health standpoint. He studied three districts, one, Italian, one, Jewish, and one, Irish. There were four hundred families, with an infant under one year of age, in each group. The twelve hundred families were then divided at once. In one group special fly protective measures were to be enforced, in the other group the absence of such measures would enable it to serve as a control. Great pains were taken to make the two groups, in other respects, entirely the same.

From these studies it was found that almost twice as many infants had diarrhea among the fly exposed group as among the fly protected group.

The significance of the diet factor in the home was also considered and it was found that almost as many infants had diarrhea as in the clean homes, other conditions being equal or as nearly equal as possible. The incidence of artificial feeding was so small, 10%, and so evenly distributed, that it did not alter the results.

In conclusion, Platt says that it is seen that flies and diet appear to be equally important and practically double the incidence of diarrhea. Still greater in importance would be artificial feeding and diet combined, since in the above experiment, the milk supply was carefully guarded.

It must be noted that this was not the first time diet etc. was considered to be a factor. Fischer(8) in 1901 makes the statement that such conditions as improper air, crowded apartments along with impure diet are frequently the cause of diarrheal conditions and all of these factors must be remedied.

Speaking more of diet and diarrhea, Hill(9) in 1916 in Boston has the following to say: "Diarrhea of infancy may be divided into three classes, one-infectious, two-nervous, three-fermentative diarrheas-(a) proteid form, (b) carbohydrate form. The carbohydrate form gives an excess acid production with consequent irritation to the mucosa and increased peristalsis.

Many factors enter into the abnormal fermentation of carbohydrates, such as microorganisms, chemical nature of the food, quantity and composition of the digestive juices, rate of absorption, and rate of motor function of the stomach and intestines.

In any discussion of the etiology of fermentative diarrhea in infants, according to Hill, heat occupies an important place. Heat favors the growth of deleterious organisms in the milk ingested and it also lowers the resistance of the child.

There are three conditions in the food that are important. 1- Too high a sugar percentage, a high sugar and a

relative low protein percentage favors acid production.

2-Too much food- that which cannot be absorbed, ferments.

3- Bad milk- Soured milk by lactic acid is not bad milk , but it is the milk that contains B.coli and acidophilus and protein etc. that produces volatile fatty acids from the carbohydrates.

Fermentative diarrhea is due to excessive production of volatile fatty acids by bacterial fermentation on the carbohydrates in the intestine, of which acetic is the especial harmful one. The first action of the volatile fatty acids is to irritate the intestine and cause increased peristalsis with an accompanying decrease in food absorption.

The bile is decomposed in an acid medium and, as a result, it cannot emulsify the fat for absorption. Neither can an emulsification of fat or soap exist in an acid medium, so with an acid content, fat absorption is greatly increased. An important thing is the loss of alkali. The sodium and potassium are used up in the neutralizing the lower volatile acids, leaving the insoluble calcium and magnesium to form insoluble soaps with the higher volatile fatty acids. This being the case there is a loss of the bases as well as fat.

Dr. Abt(12) says in his Pediatric series of 1923 that the diarrheas of infancy may be due, primarily, to an indigestion

or to an indigestion plus bacterial fermentation, or it may be ~~as~~ a bacterial fermentation with an accompanying non-digestion. If there are only a few undigested stools without excessive gas or sourness, and there is no temperature, we have to deal, probably with a simple digestion. If the stools are more frequent, are acid enough to scald the buttocks, are frothy and spurting and there are rises in temperature, then we feel sure that we have no longer a simple indigestion, but a bacterial fermentation that now dominates the picture. If the stools are frequent and foul, but not acid, the whole thing may be due to a rarer predominatingly proteolytic bacterial action, rather than to the common fermentative action on the carbohydrate and the fats.

The role of the different food elements in the causation of these diarrheas, whether they are primarily at fault or only secondarily, as a result of bacterial activity must always be considered in each case. In case of any severity, a therapy based on reduction or modification of one food element rarely leads to success, but a reduction or discontinuance of all food for a brief time is necessary.

Abt says that the carbohydrates seem to play the leading part in the diarrheas of infancy, as they are the only food elements that readily undergoes fermentation. This applies only to the artificially fed baby, fermentation is normally the pre-

dominating process, and in the medium of breast milk, sugar is naturally tolerated in large amounts.

About this time, or later, in 1924 and '25, much attention was turned toward focal infection as the cause of infantile diarrheas. Lyman(11) in 1925 says that at that time little had been said about the systemic effect of a focal infection of the ears. He says that there is a type of aurial infection which is characterized by vomiting, diarrhea and loss of weight. There is present an inflammatory condition of the middle ear and a temperature ranging from 38-40 C. The most painstaking regulation of feeding fails to control the gastro-intestinal symptoms unless the infection in the ear is recognized and relieved.

The striking features of these cases from an otological point of view are that the ear symptoms are not those characteristic of the usual mastoid abscess in children, and the ear symptoms alone are not always sufficient to indicate operation. There is seldom any post-auricular swelling and the discharge from the ear may seem quite insufficient. The decision to operate must be based on the clinical course of the patient, chiefly on the temperature and the continuance of the digestive disturbances.

Lyman places the cases into four groups. 1-Cases making perfect recoveries after paracentesis. 2-Cases in which paracenteses fail to afford relief. 3-Cases in which repeated

paracenteses and opening of both mastoid antra fail to relieve.
4-Cases in which mastoid operations are followed by amelioration of all gastro-intestinal symptoms.

Alden(12) in 1926 said that it is now well recognized that severe intoxication in infants, leading to progressive vomiting and diarrhea with dehydration and cachexia, are due, for the most part, not to food poisoning but to a toxemia of infectious origin. Autopsies on these cases have uniformly failed to show pathology in the gastro-enteric tract, while almost without exception, they have shown lesions elsewhere in the body which were usually of streptococcic origin. He reviews a series of cases in which it is found that 87.7% of these babies with gastro-intestinal symptoms leading to extreme dehydration and cachexia had a frankly purulent discharge from one or both ears. He says that a careful examination of the ears will oftentimes show ~~antrum~~ involvement and this is oftentimes the cause of the gastro-intestinal condition. These records show convincing proof that drainage of the middle ear and mastoid will give results.

Marriott(13) in the same year said that many of the symptoms occurring in infants and children which are referable to the gastro-intestinal tract, heart, lungs, nervous system and kidney are actually the result of infection localized in some other part of the body. Frequent location of such infections are in the middle ear, mastoid, or in the nasal accessory sinuses. When such infections are present any form of treatment which fa-

ils to remedy the causal infection is ineffective.

Infants are particularly susceptible to infections of the middle ear. It is well known that infections of the middle ear in young infants rarely give rise to any symptoms referable to the ears. The usual symptoms are fever, restlessness, occasionally a slight cough, vomiting and subsequently diarrhea. The gastro-intestinal symptoms very often are the most prominent, and consequently many of these cases are treated by changing the diet. It is important in this connection to bear in mind that if an infant is breast fed, or has been receiving an adequate cow's formula, properly sterilized, that gastro-intestinal symptoms with fever are rarely due to the food.

The symptoms of infection of the middle ear differ depending upon the infecting organism and the nutritional condition of the infant. Infection with a hemolytic streptococcus, especially in the case of malnourished infants, ~~is~~ likely to lead to a very severe watery diarrhea.

Marriott(14) in another paper explains more about the above mentioned type of infection. He says that infants suffering from infection other than the streptococcic, with higher temperatures do not exhibit the same symptomatology. He, also, says that the symptoms are the result of a streptococcic toxin, and that this toxin acts by damaging the capillaries. Since, in infants the gastro-intestinal tract is the seat of much greater activity than in older children, it seems that the toxin affects

the capillaries more in this portion of the body than elsewhere and as result a diarrheal condition is produced. Why this is true if the streptococcic toxin and not if the other was not explained.

Jeans(15) in Iowa City in 1926, had this to say: "There is a relationship between upper respiratory infection and a clinical picture corresponding to that which has been described under the term, cholera infantum. The infection is seldom obvious while the gastro-intestinal symptoms are prominent. The establishment of adequate drainage from the site of infection brings about prompt and complete recovery."

Sidbury(16) strikes the same note as he says, speaking of mastoiditis in infants, that as we learn more about focal infection, we find that infection in one place may give rise to definite symptoms far removed from the site of infection. He says also, that the infection in the middle ear will, in most cases, give no signs referable to the site, but will manifest itself in a gastro-intestinal upset. Also, in those cases in which the child is either breast fed or on a properly balanced and sterilized diet, or formula, that treatment of the gastro-intestinal condition is not a change in diet, because this is not the cause, as he demonstrated in a report of forty cases in which he showed that treatment of the localized infection produced a cessation of the symptoms.

The Dicks and Williams(17) have a little different idea about the otitis and gastro-intestinal condition. These workers, speaking of an epidemic of enteritis and mastoiditis in Evanston in 1927, said that the epidemic is interesting, because it was due to a primary intestinal infection and often times in the more chronic cases the mastoid lesion obscured the intestinal origin of the disease. Quoting this paper we read: "That this epidemic of enteritis associated with mastoiditis in infants was primarily an intestinal infection is shown by the results of bacteriologic examination in which the Morgan Dysentery bacillus was found, and by the fact that the epidemic was controlled through discarding all foods which were not fresh and which could not be boiled, and the adoption of measures to prevent the transfer of intestinal bacteria by the fingers of the nurse."

Evidently during the years 1925, '26, '27, the idea of middle ear infections and other focal infections causing gastro-intestinal upsets became an epidemic in itself, and it seemed to infect the majority of the writers, but in 1932, Druss(18) seems to me, summed up the whole situation in his paper, which follows: "The question of the relationship between otitis media and gastro intestinal disturbances has received considerable attention for a number of years. While it is the rule for cases of intestinal intoxication to run their course without aural involvement, at times the latter condition may co-exist, appearing before, during or after the onset of the illness. Consequently, the pathologic picture of the middle ear and mastoid will vary, depending on the presence and the degree of the otitis involvement. There

are no specific anatomic pathologic changes in the middle ear or mastoid that are characteristic for cases of intestinal intoxication.

It is fully understood that infectious agents may vary in their specificity and virulence with regard to time and location, so that no hard and fast rules can be laid down. However, from a review of the literature and from a clinical and pathologic study of the cases the preponderance of evidence favors the view that the otitic condition is not responsible for, or is the etiologic factor for the intestinal intoxication. An infection of the ear may influence the course of the illness, and it should be treated accordingly. The causative factors, however, must be looked for elsewhere."

This point of view was seen to be working itself into the minds and the writings of the clinicians, even during the past year. Blondt(19) said that infections such as otitis media, mastoiditis, tonsillitis, sinusitis, pyelitis, etc. played an important part in the etiology of diarrhea in the infant. He goes on to say that infants are more susceptible to diarrhea than adults because the gastric juices contain less pepsin, urenin, and very much less Hcl. The gastric juice of the infant is well adapted to initiate the process of digestion when human milk is fed due to the acidity of the stomach and upper portion of the intestinal tract. Consequently, diarrhea very infrequently occurs in the breast fed baby. There are conditions which decrease the gastric acidity, such as, infection accompanied by fever, exposure to a temperature

high temperature does the same thing, very often these children become sick during the heat of the day.

The pancreatic juice, bile, and succus entericus while being alkaline in reaction when they become mixed with the acid chyme coming from the stomach the whole mixture is acid in reaction, except when the gastric content is decreased by the above mentioned causes, or when foods of a high buffer content are fed such as undiluted sweet milk, the duodenal contents may become alkaline. If this occurs, bacterial flora are likely to be present in large numbers.

Protein digestion and absorption is little disturbed by diarrhea, relatively little carbohydrate is destroyed in the intestine, unless digestive or absorptive powers are impaired, when large amounts may be destroyed, resulting in the production of organic acids, which have a distinctly irritating effect on the intestinal mucosa. In diarrhea the fats are hurried through the intestine, before any appreciable quantity can be absorbed. The digestive capacity of infants for fats is less than for carbohydrates or proteins.

In the large intestine bacterial activity is usually vigorous and results in the decomposition of certain food remnants, especially carbohydrates. The most important bacteria found in the gastro-intestinal tract are B.bifidus, B.lactos, aerogenous, B.coli, B.aerogenous capsulatis(gas bacillus), Staph-
1800

lococcus and Streptococcus. When gastric secretion is decreased and the reaction becomes alkaline, due to high temperature, fever, etc., the growth of the pathogenic bacteria is increased to such an extent that digestion(intestinal)is inhibited, and toxic, irritating substances are produced which result in an inflammation and destruction of the intestinal mucosa and diarrhea.

Diarrheas that occur in well nourished infants are usually due to temporary overfeeding, contamination of food, high external temperatures or parenteral infections, while the severe forms are usually found in undernourished children, growing infants and those suffering from acute parenteral infections. This type, usually, has fifteen to twenty stools per day, resulting in severe anhydremia.

Diarrhea, if severe or prolonged, may result in severe body tissue destruction, due to: 1-Diminished absorption of food resulting in partial starvation. 2-Loss of water. 3-Loss of mineral salts, especially fixed bases. 4-Toxemia from intestinal bacteria.

Referring to Marriott(20)again, but at a later date, in fact in 1931, we find that he presents the situation from a little different viewpoint than that in a previous article. He says that due to the fact that there is no characteristic pathology found in the gastro-intestinal tract of the majority of infants succumbing to this diarrheal condition indicates that

factors other than gastro-intestinal damage must be operative, at least in those cases in which such specific diseases as dysentery can be excluded. Diarrheal diseases are more frequent in artificially fed infants, so this focuses attention on dietary factors, but a diarrhea of a severe type may occur when only minimal amounts of all of the food constituents have been fed, so there must be an other cause besides an overfeeding.

Factors such as prematurity, congenital abnormalities, especially sensitive and irritable gastro-intestinal tract or imbalance of the autonomic nervous system, may be a factor, but are not entirely adequate. Infants fed on food containing bacteria are more prone to develop diarrhea, but with the exception of bacillary dysentery, paratyphoid, and typhoid, no specific bacterial cause can be determined and it is the common thing to find a severe diarrhea developing in an infant who has presumably received only sterile food and water.

There are certain features common to all of the diarrheas resulting from parenteral infection, summer diarrhea, fermentative diarrhea, food diarrhea. There is an evidence of excessive bacterial activity in the upper portion of the gastro-intestinal tract. This is due to a lack of gastric secretion which reduces the acidity, which permits the bacterial flora to flourish. Marriott says that the bacterial travel up from the lower intestine, because it was found in his clinic that in infants suffering from diarrhea of this type discussed, the pre-

sence of colon bacilli in the stomach contents is associated with a decrease in gastric acidity.

Feeding with sweet cow's milk, which has high buffer value, is apt to neutralize the acid, while human milk, which is of a lower buffer value, is not so apt to neutralize the acid. This is one of the reasons why human milk is superior to cow's milk in infant feeding.

The reduction in the acidity is, also, caused by the afore mentioned various infections, too high temperature, outside and inside. That this decrease in acidity is an important factor has been demonstrated, or, proven to be a fact by the use of A.F.

Hartmans Buffered Lactic Acid Solution:

Lactic Acid(U.S.P.)-----15c.c.

Sodium Hydroxide-----10c.c.

Aqua Dist.-----q.s.a.d 100c.c.

This solution is strongly acid and remains so even after the addition of considerable alkali. This is fed to the infant, having added Karo or Dextrose Maltose, later protein milk can be made up with the mixture. These feedings are continued until there is a decrease in the number of stools. It has been found that when the buffered solution, or milk prepared from it, is fed that coincident with the resulting increase in gastric and duodenal acidity, the abnormal bacterial flora disappears and this is regularly associated with a cessation or amelioration of the diarrhea, which is quite strong evidence that the diarrhea is due to a decrease in acidity, which permits an increase in the bacterial flora.

Marriott has the following to say about the parenteral infections: "Parenteral infections, such as otitis media, rhinopharyngeal, which produce high fever are more apt to cause a diarrhea than pyelitis and pneumonia, because some of the organisms may be swallowed, and also, due to irritation, much alkaline mucous is produced and swallowed, which, also, helps to neutralize the acid."

He adds that there is no sharp distinction between the diarrheas of enteral and those of parenteral origin, and whatever the cause, conditions in the gastro-intestinal tract are likely to be the same. This being the case, the treatment should, in any event, be based upon the correction of these conditions,

Hardisty(21) says that the Southern states seem to be more prone to this dread disease, diarrhea, than in the northern parts of the world. This may be due in part, at least, to the hot weather and the indifferent refrigeration in the south. She seems to place much emphasis on ~~Fat~~ intolerance. She says: "Fat intolerance has long been known to be, in part, responsible for summer diarrheas in infants. When the infant's tolerance for fats is overstepped diarrhea results. The stools are, usually, pale and crumbly at first, later pale, loose and, finally, acid green and contain curds,"

McLester(22) is the author of a good common sense state-

ment in connection with the infantile diarrheas. He says: "The digestive tract of the infant is always working rather close to its functional capacity and there is but a small margin of safety, so that any condition which lessens the function of digestion and absorption, may lead to the accumulation of food in the intestinal tract which is readily broken down by the organisms present, with the formation of irritating products. When an infant is given an adequate diet, properly sterilized, diarrhea is of infrequent occurrence, except in the presence of parenteral infection."

Dodd, Minot and Casparius(23) confined their paper to the nonspecific diarrheas of the severe and frequently fatal type called, by them alimentary intoxication. During the summer of 1930 there was almost an epidemic, in Nashville, of this alimentary intoxication. In many the accepted forms of treatment gave no results. They seemed to think that there was some unidentified toxic agent.

They found a hyperguanidemia and the clinical picture of bloody vomitus and diarrhea and acidosis, associated with nervous hyperexcitability was similar to that in animals in which there had been an increased guanidine in the blood. Quoting their paper: "The antagonistic action between calcium salts and guanidine has been repeatedly demonstrated(Fisher, Major and Stephenson). The efficiency of calcium treatment in animals with an increase in the guanidine in the blood has been described (Minot, Cutler, Minot). Animals receiving calcium previous to

or early in the course of the intoxication could be prevented from developing symptoms of poisoning in spite of high guanidine levels in the blood, while animals already severely toxic could be cured by persistent calcium therapy." They state that studies now in preparation seem to indicate that necrotic or autolyzing tissue of various types may serve as a source of guanidine. The relation that this may have to severe dehydration can be proved, only, by further investigation.

The clinical results as well as those of animal experiments seem to indicate that the efficiency of calcium lies in its antagonistic to guanidine. In animal experiments, it has been repeatedly demonstrated that one is not dealing with a hypocalcemia, but rather with an apparent need for extra calcium due to the presence of guanidine. The guanidine is not influenced by the treatment, in fact, in some instances the level continues to rise for a day or two even when considerable relief from symptoms has been attained by calcium medication. If a high guanidine level continues too long without the inhibiting action of extra calcium, irreparable damage to the tissue may result and in themselves cause death. This article is of the ultra scientific and for the ordinary practitioners it is not of much aid, but possibly from further experimentation more will be determined and something developed that will be of some practical assistance to the practitioners in general.

Marriott (24) in his book, *Infant Nutrition*, makes a few

statements that, so far have not been mentioned. He says that that underfeeding may lead to diarrhea would appear at first sight unlikely, yet this is a very frequent cause. This starvation or hunger diarrhea is more likely to be seen in infants who have been quantitatively and qualitatively underfed for considerable periods of time, until they have become undernourished, than in the case of healthy infants subject to short periods of starvation or decreased food intake. Too low a protein, carbohydrate, mineral salts and certain of the vitamins may bring about the condition. In the presence of hunger, hypermotility of the gastro-intestinal tract is observed and experimental evidence seems to indicate that such hypermotility is a direct result of lowering of the blood sugar content.

An adequate intake should be included in the category of underfeeding. When the water intake is insufficient to cover the water output by way of the urine, stools, respiration and perspiration, desiccation of the body, or anhydremia occurs. One of the results of anhydremia is diarrhea.

In summarizing then, we find that the ancient practitioners recognized the fact that there was an infantile diarrhea and their explanation of it was that it was due to overfeeding, catching cold, teething, too much bile or phlegm. This was as good as we can do today, or at least it is the basis on which we base our explanation today. In the early years of the nineteenth century, the literature points out the fact that the dia-

rrheas of infancy were due to improper food, but there was no real scientific data to prove this. With the beginning of the twentieth century, a specific bacillary dysentery was proven. In 1911 Vincent came out with his work concerning the presence of organisms in milk, some beneficial, others, harmful. The beneficial ones producing an acid medium in which the harmful organisms are inert. A good share of the etiology is based around this today.

Around 1916 a good deal of work was done, proving that flies and filth are the cause of diarrheas due to the contamination of the food. Beginning with 1925 there seems to be a flooding of the literature with the information that middle ear infections are the cause of diarrheas in the infants. This idea was held in ~~1952~~ grace by the profession without argument against it, but in 1932 Druss says that this is not the cause ~~of cause~~ of infantile diarrheas, but that it might influence the course of the illness. However the idea of middle ear infection should be kept in mind and whether it is the etiological factor or not, does not matter so much, because we know that as long as it is present the diarrheal condition is aggravated, so the ear should be thought of in every case of diarrhea and let the findings determine the course of treatment.

In the more recent literature we find this idea prevalent; high temperatures seem to decrease the gastric secretion

and as a result the gastro-intestinal acidity is ~~reduced~~, providing a more suitable medium for the growth and multiplication of harmful organisms. Also, we find that overfeeding, as well as, underfeeding is a cause of diarrhea in the infant. Then, to be more scientific, or should I say more laboratory minded, we find that ~~in~~ some of the more severe cases are due to a hyperguanidinemia and a relative decrease in the calcium of the blood.

In conclusion I might use to advantage the words of Marriott: "Diarrhea should not be considered a disease, *sui generis*, but as a symptom resulting from a variety of causes." That there is a variety of causes must be appreciated by anyone reading the above paper. So, quoting, ~~from the~~ introduction, these words: "without a knowledge of the cause, therapeutics is not only difficult, but hopeless," we should realize, in the face of the variety of causes, how utterly hopeless would be our therapeutic endeavors without a knowledge of the cause or causes.

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